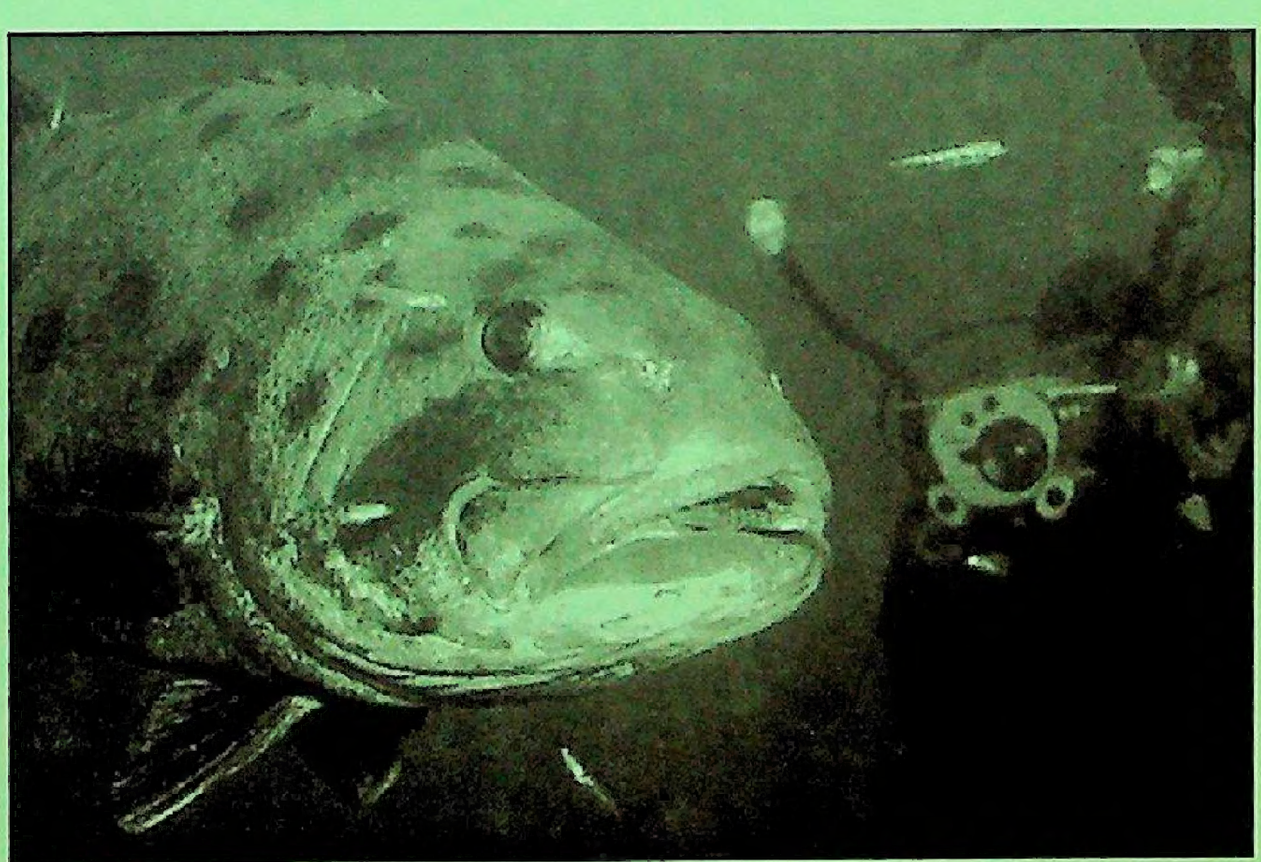
CALIFORNIA FISH and GAME

"CONSERVATION THROUGH EDUCATION"

VOLUME 87 SUMMER 2001 NUMBER 3



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EDITOR'S ACKNOWLEDGEMENT

In April 2001 Jim Orsi and Dave Kohlhorst passed to us their editorial responsibilities. We take this opportunity to personally acknowledge their tireless efforts for the past 6 years as co-editors-in-chief of *California Fish and Game*. It is noteworthy that Dave and Jim served as co-editors from 1995 to 2001, the longest term of any editorship in our journal's history. The continued quality and importance of *California Fish and Game* is the direct result of their expertise, time, and energy. As new editors we understand the level of devotion and care required to maintain a peer-reviewed scientific journal. Dave and Jim have set a high standard for us to follow, and have helped us in the transition as new editors. We appreciate their past and present contributions as editors, and hope to continue their high standard for the journal. We offer our personal thanks to Jim and Dave for all of their efforts.

Todd Keeler-Wolf
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Juvenile giant kelpfish, *Heterostichus rostratus*, cleaning a giant sea bass, *Stereolepis gigas*. Cover photo by Kathy deWet-Oleson.

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OBSERVATIONS OF CLEANING BEHAVIOR BY GIANT KELPFISH, *HETEROSTICHUS ROSTRATUS*, ISLAND KELPFISH, *ALLOCLINUS HOLDERI*, BLUEBANDED GOBY, *LYTHRYPNUS DALLI*, AND KELP BASS, *PARALABRAX CLATHRATUS*, ON GIANT SEA BASS, *STEREOLEPIS GIGAS*

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We observed cleaning behavior by four fish species, island kelpfish (*Alloclinus holderi*), bluebanded goby (*Lythrypnus dalli*), giant kelpfish (*Heterostichus rostratus*), and kelp bass (*Paralabrax clathratus*) on the giant sea bass, *Stereolepis gigas*, at Anacapa and Santa Catalina Islands in southern California. These are the first documented observations of cleaning behavior by any of these fishes. Most observations occurred at a single rocky outcrop at Anacapa Island. This site seasonally harbors large numbers of giant sea bass. Here we report on cleaning behavior by four fish species on giant sea bass. For the past 30 years, giant sea bass were rare in southern California waters and little was known about cleaning behavior on this species.

The giant sea bass, *Stereolepis gigas*, is found from Humboldt Bay, California to the Gulf of California, most commonly from Point Conception southwards. The species reaches a length of 2.26 m and is found from nearshore waters to depths of at least 46 m. Adults usually live over rocky bottoms and in kelp beds. Juveniles may also frequent sandy habitats (Eschmeyer et al. 1983, Crooke 1992, Shane et al. 1996). Though little is known of their biology, it is believed that they were once relatively common in southern California (Holder 1910). However, by the 1970s, overfishing by recreational and commercial fishermen had substantially depressed the California population (Crooke 1992). Since 1982, the species has been protected from both recreational and commercial harvest. Commercial operators are allowed one giant sea bass per day if taken as incidental catch in a gill or trammel net.

The 1982-83 El Nino-Southern Oscillation produced a relatively strong year class and currently the species appears to be making at least a modest comeback (Crooke 1992). Beginning in 1994, one of us (K. d.-O.) occasionally sighted giant sea bass at Anacapa Island, the eastern-most of the northern Channel Islands in southern California. In 1997, she noted an aggregation of >30 subadult fish in these waters,

leading to her ongoing monitoring of this species around Anacapa Island. Based on about 800 dive surveys conducted from 1994 to 2001, giant sea bass are only seen at Anacapa Island between May and September. Between 1997 and 2000, 233 dives between May and September were made around the island. Giant sea bass were noted on 108 (46%) of these dives.

During diving observations between 1997 and 2000, giant sea bass at Anacapa Island were observed being cleaned or posing for cleaning on 11 occasions. In addition, on eight days during July through September 2000, a camera was placed on a tripod near cleaning stations at Anacapa Island and recorded 33 instances of posturing and eight cleaning episodes.

Almost all of the cleaning observations occurred at a site that consistently has the largest sea bass aggregations. As many as 30 individuals in 1997 and 12 to 15 individuals in subsequent years have been observed during dives at this location. This is a rocky outcrop on the north side of the island that plateaus in 16 m of water and has a steep vertical face dropping to a depth of 21 m. The vertical face is notched by a series of indentations and giant sea bass often hover in these clefts. When the first sightings of giant sea bass were made in 1994 this feature supported a kelp forest. However, the kelp vanished in 1996 and has not returned.

Island kelpfish as cleaners: The first observation of cleaning was made in June of 1997 when an approximately 1-m long giant sea bass approached one of the clefts in the reef and opened its mouth and operculum and flared its pectoral fins. Immediately afterwards, an island kelpfish, *Alloclinus holderi*, left the overhang, swam to the giant sea bass, picked at the skin between 1 of the fish's nostrils and opercula, then swam back to the ledge and did not return. Despite this, the giant sea bass kept its mouth open for approximately two minutes before it left when approached by another diver.

The behavior by the giant sea bass was unusual because, in California waters, hosts generally strike cleaning poses in response to the stimulus of the cleaning activity (Hobson 1971). This has been explained as a response to the relative rarity of cleaners within a species and the inability of the host to differentiate between potential and nonpotential cleaners (Hobson 1971, 1976). However, based on analysis of our video footage, posturing was observed 33 times, cleaning was observed only 8 times or 24%. This indicates that giant sea bass will pose at a specific location where cleaning has occurred, even in the absence of an active cleaner.

All eight cleaning episodes caught on videotape involved island kelpfish. Island kelpfish were observed to make brief departures from the reef anywhere from one to three times during a cleaning session. The movements of island kelpfish were very quick, and they were in contact with the host for a few seconds before retreating back to the reef. Whenever island kelpfish initiated cleaning, the giant sea bass responded by posturing. Review of the 33 posturing episodes on videotape show duration of posturing ranging from 5 to 126 seconds (mean 54 seconds) (Table1). In 75% of the posturing displays cleaning was not observed, yet it is possible that cleaning was occurring on the side of the fish that was away from the camera and against the reef. Movements of island kelpfish were so rapid that it was difficult to discern if the fish was targeting the copepods on the face of giant sea bass, or if they were simply picking at

the skin.

Bluebanded goby as cleaner: Posing for cleaning has been observed on eight occasions during survey dives at this location, cleaning was observed four times. At this feature, island kelpfish conducted most of the cleaning. However, in one instance, a bluebanded goby, *Lythrypnus dalli*, was observed cleaning. This individual left the reef and spent about 15 seconds picking near the eye of the giant sea bass before retreating. Although bluebanded gobies are abundant at this location, this was the only time one has been observed cleaning.

Table 1. Duration, in seconds, of cleaning postures exhibited by giant sea bass during 2000.

	Event												
Date	1	2	3	4	5	6	7	8	9	10	11	12	13
7 July	35												
13 August	26	10	27	11	10	5	29	37	17	8	94	82	93
19 August	88	92	69	22	126	15	44						
1 September	113	36	24	80	35								
2 September	79												
10 September	85	89	81	72									
15 September	64	101											

Giant kelpfish as cleaners: Cleaning was also observed on 3 occasions (2 in 1997 and 1 in 1998) at a different site on the south side of the island. This site consists of sparse rocks and a few isolated strands of giant kelp, *Macrocystis pyrifera*, in about 12 m. During the first of these observations, 4 giant sea bass were seen hovering 1 above the other, oriented with their faces thrust into the strands of kelp. No posturing other than the head-in orientation to the kelp was observed. From a distance, a number of 6-8-cm juvenile giant kelpfish, *Heterostichus rostratus*, could be seen swarming over the fish (Fig. 1). When approached, 3 of the sea bass swam away, but 1 remained. As the remaining giant sea bass hung almost motionless near the kelp, juvenile giant kelpfish would leave the shelter of the kelp; pick at the giant sea bass' eyes, gill plate, and pectoral fins; swim into and out of its mouth; then return to the kelp stipes. As many as 20 giant kelpfish swarmed about the giant sea bass at any one time.

On the following dive, within five minutes, a giant sea bass arrived and positioned itself in the same location as before. Immediately, juvenile giant kelpfish returned to cleaning and continued the activity on and off for 35 minutes. This cleaning bout was interrupted on 2 occasions when a California sea lion, *Zalophus californianus*, disturbed the fish by swooping close by. Following the first disturbance, the fish moved slightly away, returned to the same spot and cleaning resumed. During the third observation, a giant sea bass was again observed being cleaned by juvenile giant kelpfish. This time, there were 3 cleaners present and the kelp stipe was a young plant only extending about one meter from the holdfast. The cleaning lasted for about 2 minutes before the host moved away.

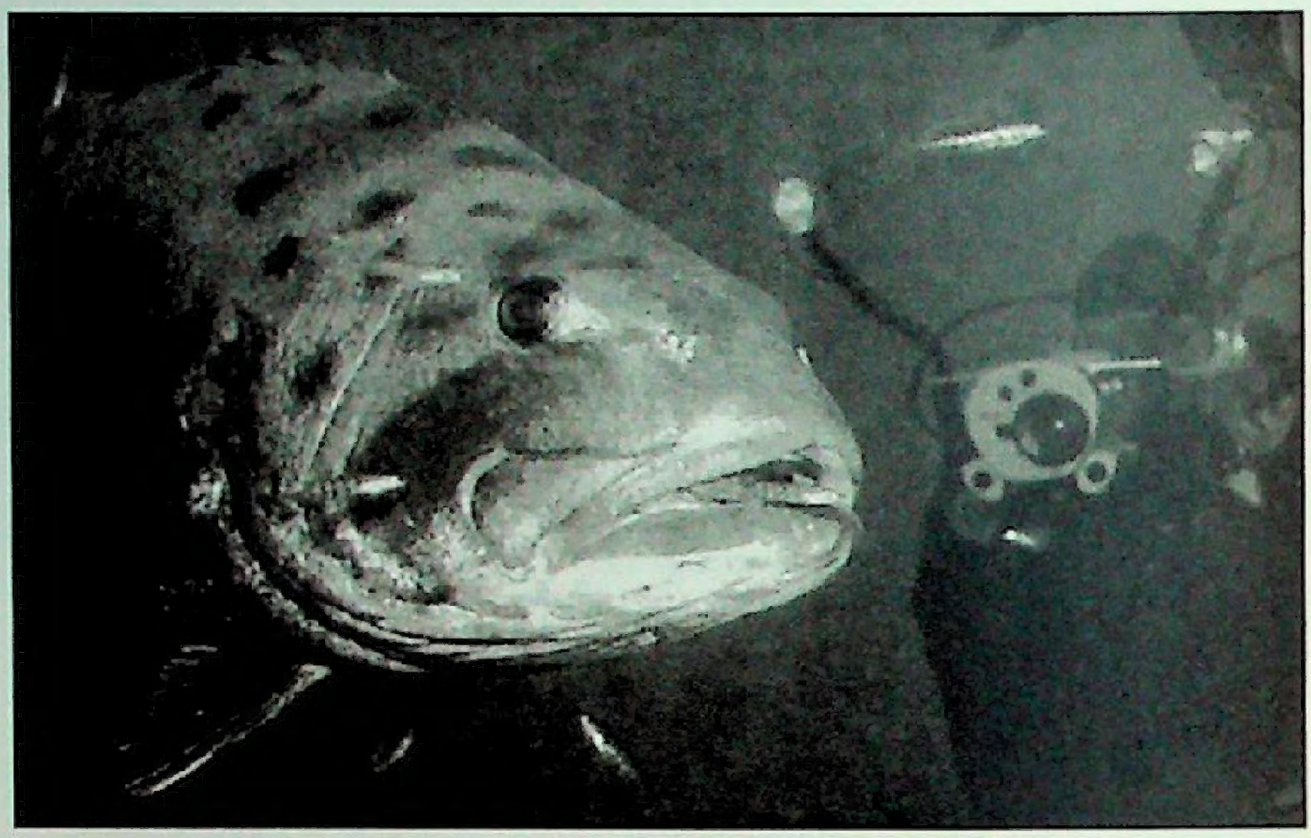

Figure 1. Juvenile giant kelpfish, *Heterostichus rostratus*, cleaning a giant sea bass, *Stereolepis gigas*. Photo by Kathy deWet-Oleson.

Kelp bass as cleaners: Lastly, during 6 dives (3 in September 2000 and 3 in July 2001) at a site at Catalina Island, K. d.-O. noted juvenile kelp bass, *Paralabrax clathratus*, cleaning giant sea bass. This site is characterized by a moderate slope from 9 to 30 m deep with a bottom of coarse sand and scattered rock and a thick kelp bed. Here, giant sea bass often were observed with a head-in orientation to the kelp. Between 1 and 6 juvenile kelp bass would pick at the area primarily around the head, pectoral and pelvic fins.

Summary: These are the first documented observations of cleaning behavior by island and giant kelpfishes, bluebanded goby, and kelp bass, bringing the number of species that have been noted as cleaners off California to 18 (Table 2). As with the 4 species discussed in this paper, most of this cleaning behavior has been carried out by juvenile fishes. This appears to be the case because picker-type predators are preadapted for cleaning and the juveniles of many species are pickers (Hobson 1971). Juvenile giant kelpfish, kelp bass and adult island kelpfish and bluebanded gobies prey on small crustaceans and other benthic prey (Quast 1968; M. Love, unpublished data) and it is probable that some members of each species would be capable of cleaning.

Several aspects of the juvenile giant kelpfish behavior appeared unusual. First, there were an atypically large number of individuals cleaning at any one time. As most observers have noted, cleaning in California is usually conducted by only a few individuals per species per cleaning episode (Hobson 1971). However, as many as 15 to 20 individual giant kelpfish could be involved in the cleaning of a single giant sea bass. Although giant kelpfish rarely venture away from algal shelter (Hobson 1971,

Table 2. Fishes known to engage in cleaning behavior in California waters.

Scientific Name	Family	Common Name	References
Alloclinus holderi	Labrisomidae	Island kelpfish	Current study
Brachyistius frenatus	Embiotocidae	Kelp perch	Limbaugh (1955), Hobson (1971)
Chromis punctipinnis	Pomacentridae	Blacksmith	Turner et al. (1969)
Embiotoca jacksoni	Embiotocidae	Black perch	Limbaugh (1955)
Girella nigricans	Kyphosidae	Opaleye	DeMartini and Coyer (1981), Sikkel (1986)
Halichoeres semicinctus	Labridae	Rock wrasse	Hobson (1971)
Hermosilla azurea	Kyphosidae	Zebraperch	DeMartini and Coy (1981), Sikkel (1986)
Heterostichus rostratus	Clinidae	Giant kelpfish	Current Study
Hypsurus caryi	Embiotocidae	Rainbow seaperch	Gotshall (1967)
Lythrypnus dalli	Gobiidae	Bluebanded goby	Current study
Medialuna californiensis	Kyphosidae	Halfmoon	Hixon (1979)
Oxyjulis californica	Labridae	Senorita	Limbaugh (1955), Hobson (1971)
Paralabrax clathratus	Serranidae	Kelp bass	Current study
Phanerodon atripes	Embiotocidae	Sharpnose seaperch	Gotshall (1967), Hobson (1971)
Phanerodon furcatus	Embiotocidae	White seaperch	Hobson (1971)
Rhachochilus vacca	Embiotocidae	Pile perch	Limbaugh (1955)
Semicossyphus pulcher	Labridae	Sheephead	Coyer (1980)
Xenestius californiensis	Haemulidae	Salema	Sikkel (1986)

Feder et al. 1974), these juveniles readily left the security of the kelp.

What might account for this unusual behavior? Not only do giant kelpfish require algae for protection, they also feed on the microinvertebrates living on the plants (Quast 1968, M. Love, unpublished data). During the summer of 1996, most of the kelp beds off Anacapa were lost due to the effects of a strong El Nino event (D. Schroeder, Marine Science Institute, University of California, Santa Barbara, personal communication). The several stipes where cleaning was observed were among the few remaining on the south side of the island. It is possible that a combination of shrinking habitat, leading to increased kelpfish densities, and concomitant reduced food supply may have lead these juveniles to assume a more active cleaning role.

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LITERATURE CITED

Coyer, J.A. 1980. Possible cleaning behavior by a juvenile California sheephead, *Semicossyphus pulcher* (Labridae). Bulletin of the Southern California Academy of Science 79:125-126.

Crooke, S.J. 1992. Giant sea bass. Pages 153-155 in: W.S. Leet, C.M. Dewees, and C.W. Haugen, editors. California's living marine resources and their utilization. California Sea Grant, UCSGEP-92-12.

DeMartini, E.E. and J.A. Coyer. 1981. Cleaning and scale eating in juveniles of the kyphosid fishes *Hermosilla azurea* and *Girella nigricans*. Copeia 1981:785-789.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific Coast fishes of North America. Houghton Mifflin, Boston, Massachusetts, USA.

Feder, H.M., C.H. Turner, and C. Limbaugh. 1974. Observations on fishes associated with kelp beds in southern California. California Department of Fish and Game, Fish Bulletin 160.

Gotshall, D.W. 1967. Cleaning symbiosis in Monterey Bay, California. California Fish and Game 53:125-126.

Hixon, M.A. 1979. The halfmoon, *Medialuna californiensis*, as a cleaner fish. California Fish and Game 65:117-118.

Hobson, E.S. 1971. Cleaning symbiosis among California inshore fishes. Fishery Bulletin 69:491-523.

Hobson, E.S. 1976. The rock wrasse, *Halichoeres semicinctus*, as a cleaner fish. California Fish and Game 62:73-78.

Holder, C.F. 1910. The Channel Islands of California. Hodder and Stoughton, New York, New York, USA.

Limbaugh, C. 1955. Fish life in the kelp beds and the effects of kelp harvesting. University of California Marine Resources, Institute of Marine Resources Reference 55-9:1-156.

Limbaugh, C. 1961. Cleaning symbiosis. Scientific American 205:42-49.

Losey, G.S. Jr. 1971. Communication between fishes in cleaning symbiosis. Page 45-76 *in*: T.C. Cheng, editor. Aspects of the biology of symbiosis. University Park Press, Baltimore, Maryland, USA.

Quast, J.C. 1968. Observations on the food of the kelp-bed fishes. Pages 109-142 *in*: W. J. North and C.L. Hubbs, editors. Utilization of kelp-bed resources in southern California. California Department of Fish and Game, Fish Bulletin 139.

Shane, M.E., W. Watson, and H.G. Moser. 1996. Polyprionidae: Giant sea basses and wreckfishes. Pages 873-875 *in*: H.G. Moser, editor. The early stages of fishes in the California Current region. California Cooperative Oceanic Fisheries Investigations Atlas No. 33.

Sikkel, P.C. 1986. Intraspecific cleaning by juvenile salema, *Xenestius californiensis*. California Fish and Game 72:170-172.

Turner, C.H., E.E. Ebert, and R.R. Given. 1969. Man-made reef ecology. California Department of Fish and Game, Fish Bulletin 146.

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DIFFERENCES IN MOURNING DOVE PRODUCTIVITY AMONG THREE TIME PERIODS AT GRAY LODGE WILDLIFE AREA, CALIFORNIA

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We used published and unpublished data to compare mourning dove, *Zenaida macroura*, recruitment among the 1949–50 (early), 1979–80 (middle), and 1992–95 (late) periods in riparian habitat at Gray Lodge Wildlife Area, California, to document any differences that corresponded to the long-term decline of doves in California (as estimated by the U.S. Fish and Wildlife Service's annual Call-count Survey). Estimates of true nest success, fledglings produced per nesting attempt, and fledglings produced per active dove pair, were highest in the early period, lowest in the middle period, and low to moderate in the late period (nest success: 44–56% early, 25–29% middle, 24–35% late; fledglings/nest attempt: 1.20–1.44 early, 0.78–0.91 middle, 0.81–1.03 late; fledglings/pair: 5.93–6.58 early, 2.40–3.40 middle, 5.00–5.60 late). In the early period, high production coincided with the warmest and driest spring weather and an active predator control program, conditions thought to boost dove production. However, based on banding estimates of survival, fledgling production/pair during each period should have been more than adequate to increase breeding populations (2.5 required) (with the exception of 1980). Therefore, continued population decline in California must result from landscape-scale habitat alteration, poor survival, or both, and not recruitment; or high recruitment at Gray Lodge was not representative of California nesting doves (or riparian habitats) in general; or the three periods during which data were collected at Gray Lodge were too infrequent relative to the 47-year time period to detect long-term change in recruitment. Initiation of a wing-collection survey to monitor harvest age ratios and an operational banding program to estimate survival would ultimately provide more predictable data sets for analyses of long-term trends in annual population status than would additional analyses of historical nesting data.

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INTRODUCTION

Mourning doves, *Zenaida macroura*, have declined steadily in the Western Management Unit (WMU: Washington, Oregon, California, Idaho, Nevada, Arizona, Utah) since 1966 (U.S. Fish and Wildlife Service [USFWS] Call-count Survey; Dolton and Smith 1999[2]). In California, doves declined from averages of >24 doves heard/route in the 1960s to about 10 in the 1990s, a decline of 2.6% per year (Dolton and Smith 1999); additionally, dove densities decreased 83% in the Central Valley between 1966–70 and 1983–87 (from 33/route to 6/route; Reeves et al. 1993). If declining population trends continue, managers may change harvest management strategies in the WMU. Investigations of historical recruitment data might prove useful to suggest reasons underlying dove population trends and, thus, support harvest and habitat management strategies.

Specific causes of the decline have not been determined, but long-term changes in productivity or habitats are likely important (Reeves et al. 1993). Based on recoveries of doves banded during 1964–74 (Tomlinson et al. 1988), at least 2.5 young must be fledged/pair in California annually to maintain stable population trends (Reeves et al. 1993). However, despite California supporting an estimated 25% of the WMU mourning dove breeding population (Reeves et al. 1993), little production information has been obtained to see if this level has been attained historically. Until Miller et al. (2001) examined dove recruitment in northern California in the 1990s, available production data were very old (e.g., McClure 1950, Cowan 1952); however, these data provide a potentially useful baseline for comparison with other time periods. Our objective was to determine if nesting success and fledgling production differed among three time periods (defined by the existence of historical data sets) at Gray Lodge Wildlife Area, Butte County, California, and to test the hypothesis that if deteriorating recruitment is contributing to lower California populations long-term, then nest success and other parameters at Gray Lodge should have been relatively higher in the earlier periods.

METHODS

We compared mourning dove productivity at Gray Lodge during three periods: 1) Early: 1949–50 (Cowan 1952); 2) Middle: 1979–80 (Geissler et al. 1987: nationwide study included Gray Lodge as a study site); and 3) Late: 1992–95 (Miller et al. 2001). We used published data from Miller et al. (2001) for the late period, and we obtained original raw nesting data from J. Cowan, Gridley, California, for the 1949–50 study and from D. D. Dolton, U.S. Fish and Wildlife Service, Laurel, Maryland, for the 1979–80 study. To remain consistent, we used all nests from all three periods in riparian habitats only, except we did not use nests that had fledglings on the first visit or were never occupied by adults. We used nests located during searches from mid-March to mid-September.

[2]Dolton, D.D., and G.W. Smith. 1999. Mourning dove breeding population status, 1999. U.S. Fish and Wildlife Service, Laurel, Maryland.

We obtained annual rainfall and temperature data for the March through May period at Colusa, California, which is the nearest (20 km) weather station to Gray Lodge, using Climatological Data Reports for California (National Oceanic and Atmospheric Administration 1949-50, 1979-80, 1992-95; Miller et al. 2001).

The size of Gray Lodge increased from about 1,000 ha in 1949–50, to 3,400 ha in 1979–80 and 3,500 ha in 1992. In the early period, riparian habitat was restricted (Cowan 1952), but this vegetation subsequently spread continuously along watercourses and wetlands as the area expanded over time (Cloyd 1999). In all three periods, investigators consistently obtained nest data primarily in riparian habitat, principally willow, *Salix* spp. Therefore, we only used nests in this habitat to maintain comparability among periods. Nests were found in other tree species, but these differed among periods. Inclusion of these nests could have introduced bias if nest success and productivity differed by habitat type (Green 1977).

Investigators used similar methods to locate active dove nests in all periods by searching riparian habitat thoroughly to locate nests. The frequency with which investigators searched and re-checked active nests varied by period: 1) every 1–19 days in 1949–50, 2) once/week in 1979–80, and 3) once every 3–5 days in 1992–95. We classified a nest as successful if at least one nestling survived to 10 days of age (Geissler et al. 1987) to avoid analysis difficulties associated with the inconsistent length of time dove nestlings are dependent upon parents (Hitchcock and Mirarchi 1984, Olson et al. 1991).

We obtained the date of nest initiations by back-dating from known-aged eggs or nestlings. The difference between the date of the first nest initiation and when the last nest fledged or was destroyed equaled the nest season duration. We estimated the maximum number of active pairs as the greatest number of active nests found on one day (Schroeder 1970). This is actually a conservative estimate, because not all pairs have active nests at any given time (Lowe 1956). Total nesting attempts was the total number of nests monitored during the nesting season. We estimated nesting attempts/active pair, fledglings produced/active pair, fledglings produced/nesting attempt, and fledglings produced/successful nest for each period.

We estimated nest success (proportion of monitored nests that fledged at least one young) for comparisons among periods. We used the discrete version (Johnson 1991) of the Green estimator (Green 1989) to convert the apparent nest success rates (successful nests/total nests) to values that approximate true success for all three periods. This estimator removes the bias of apparent nest success rates, as discussed in Mayfield (1961), by assuming that the probability of finding a nest is proportional to the length of time it was viable. The equation is:

$$H = s^L L(s - 1)/s^L - 1,$$

where:

H = apparent nest success rate
s = daily nest survival rate
L = length of nesting interval in days
and s^L = discrete nest survival rate.

We estimated standard error of the success rates using:

$$SE = \sqrt{s(1-s)/n}$$

where:

s = nest success rate

n = number of nests.

We compared differences in nest success rates among years, between years within periods, and among the periods using a chi-square statistic (Sauer and Williams 1989, SAS Institute 1989).

RESULTS

The years 1949 and 1950 were the driest, and 1949, 1950, and 1992 were the warmest of the 8 years studied (Table 1) (although total rain was high in 1949, 92% of the rain fell prior to 18 March, before onset of measurable nesting effort, so rainfall in 1949 was effectively the lowest). Years 1979 and 1980 were the coolest (although dry), 1992 and 1994 were warm and dry, and 1993 and 1995 were wet and cool.

Table 1. Total rainfall during March–May and departure from the long-term mean (1961–90) (8.71 cm), and average high temperature during April and departure from the long-term mean (1961–90) (14.4°C) at Colusa, California (nearest weather station to Gray Lodge), during 1949–50 (early period), 1979–80 (middle period), and 1992–95 (late period).

	March–May rainfall (cm)		April high temperatures (°C)	
	Total rain	Departure	Temperature	Departure
1949	16.92[a]	+ 8.21	17.11	+ 2.71
1950	3.86	- 4.85	16.61	+ 2.21
1979	6.15	- 2.56	14.22	- 0.18
1980	7.44	- 1.27	15.33	+ 0.93
1992	9.45	+ 0.74	16.89	+ 2.49
1993	11.48	+2.77	15.33	+ 0.93
1994	6.02	- 2.69	16.06	+ 1.66
1995	25.27	+ 16.56	14.78	+ 0.38

[a] 92% of the rain (15.56 cm) fell in March, all prior to March 18, just before doves began to nest.

The longest nesting seasons occurred in 1949, 1950, 1979, and 1995 (≥ 170 days) and the shortest in 1980 and 1993 (155–156 days) (Table 2). The date of first initiations of sampled nests annually ranged from 14 March to 3 April and were earliest in 1949 and 1994 and latest in 1992 and 1995; whereas, the dates of last nest initiations ranged from 2 August to 25 August (Table 2). Nest initiations ceased earliest in 1980 and 1993

and latest in 1992 and 1995, and fewer days elapsed between first and last nest initiations in 1980 and 1993 than in other years (128 vs. 145–157 days) (Table 2).

Table 2. Earliest and latest initiation dates of sampled nests and duration of the nesting season for mourning doves at Gray Lodge Wildlife Area, in the Central Valley, California, 1949–50 (early period), 1979–80 (middle period), and 1992–95 (late period).

	Early period		Middle period		Late period			
	1949	1950	1979	1980	1992	1993	1994	1995
First nest initiation	14 Mar	26 Mar	28 Mar	28 Mar	1 Apr	30 Mar	19 Mar	3 Apr
Last nest initiation	17 Aug	21 Aug	23 Aug	2 Aug	25 Aug	4 Aug	15 Aug	25 Aug
Days between first and last nest	157	149	149	128	147	128	150	145
Last active nest	14 Sep	18 Sep	21 Sep	30 Aug	12 Sep	31 Aug	2 Sep	18 Sep
Nest season duration (days)	185	177	178	156	165	155	168	170

Mean nest success estimates ranged from 44–56% during 1949–50, 25-29% during 1979–80, and 24–35% during 1992–95 (Table 3). There was an overall year effect in nest success ($\chi^2 = 29.7$, df = 7, $P < 0.0001$), and there was an overall difference among periods ($\chi^2 = 20.8$, df = 2, $P < 0.0001$). Specifically, nest success in 1949–50 was significantly higher than in 1979–80 ($\chi^2 = 20.2$, df = 1, $P < 0.0001$) and in 1992–95 ($\chi^2 = 16.9$, df = 1, $P < 0.0001$). Nest success did not differ between the middle and late periods ($\chi^2 = 1.4$, df = 1, $P = 0.233$), but differed significantly among years in the late period with success during 1993 and 1994 higher than during the other 2 years ($\chi^2 = 7.8$, df = 3, $P = 0.051$).

Investigators found the fewest number of nesting pairs, total nest attempts, total successful nests, and total fledglings during 1949–50, and the most during 1992 and 1994 (Table 3). Nesting attempts/active pair were highest in 1992, 1994, and 1995; moderate in 1949–50 and 1993; and low in 1979–80 (Table 3). In contrast, the largest number of fledglings/active pair occurred in the early period (5.9–6.6) and the lowest in the middle period (2.4–3.4), with a return to large numbers in the late period (5.0–5.6) (Table 3). Doves produced ≤ 1.0 fledglings/nesting attempt in the middle and late periods, compared to 1.2–1.4 during the early period. There was no trend for fledglings/successful nest, with < 2/nest (Table 3).

DISCUSSION

Use of nesting data from three relatively short periods to estimate change over a 47-year time line (1949–95), places limits on interpretation of our results, because no estimates are available for the intervening years, and we chose the three sample periods based on available data. With this caveat, nest success and most productivity measures suggested that doves produced more young per pair during the early period, and there was a tendency for higher productivity in the late period compared to the

Table 3. Mourning dove nest success and productivity parameters at Gray Lodge Wildlife Area, California, 1949–50 (early period), 1979–80 (middle period), and 1992–95 (late period).

	Early period		Middle period		Late period			
	1949	1950	1979	1980	1992	1993	1994	1995
Nest success[a]	0.44	0.56	0.29	0.25	0.29	0.35	0.35	0.24
Standard error of success	0.06	0.07	0.04	0.04	0.03	0.04	0.03	0.03
Active nesting pairs[b]	15	12	42	44	61	26	52	24
Total nest attempts	74	55	157	136	338	126	301	165
Total successful nests	47	40	77	61	166	69	166	72
Total fledglings	89	79	143	106	323	130	291	133
Nesting attempts/ active pair	4.93	4.58	3.74	3.09	5.54	4.85	5.79	6.88
Fledglings/active pair	5.93	6.58	3.40	2.40	5.30	5.00	5.60	5.54
Fledglings/nesting attempt	1.20	1.44	0.91	0.78	0.96	1.03	0.97	0.81
Fledglings/ successful nest	1.89	1.98	1.86	1.74	1.95	1.88	1.75	1.85

[a] Nest success rates are apparent rates (Mayfield 1975) transformed to true rates (Green 1989, Johnson 1991).

[b] Apparent maximum number of active pairs, estimated as the maximum number of active nests found on any 1 day (Schroeder 1970).

middle period (more nests/pair and fledglings/pair, but not nest success). There were no meaningful differences in average fledgling production/successful nest among periods, not an unexpected result (Fichter 1959), because predation and other causes of loss affect both eggs of the clutch simultaneously.

In the Central Valley, as in other temperate regions, dove production is sensitive to spring weather. For example, in 2 of the 4 years of the field work that provided late period data for our study (Miller et al. 2001), above average rainfall in March–April and below average high temperatures in April were associated with lower production; whereas, in the 2 years with warm, dry springs, doves realized higher nest success and produced a larger number of nests, fledglings, and fledglings/nest. Likewise, the consistent warm and dry weather during the early period supported the higher nesting success, consistently longer nesting seasons, and higher production indices (e.g., fledglings/nest attempt and fledglings/pair) recorded then. In contrast, the wider nest search and re-check intervals, the smaller area available for nests, and the part-time nature of the field work in the early period, contributed to the discovery of fewer nests, pairs, and fledglings, then, compared with the later periods.

Managers conducted broad-scale professional predator control during the early period (J. B. Cowan, California Dept. of Fish and Game [retired], unpubl. data), and this could have increased early period nest survival; only ad hoc and inconsistent control followed subsequently. Additionally, the restricted extent of riparian habitat in the early period would have facilitated the predator control program. In comparison, the diverse habitat mosaic that developed by 1979 probably sustained relatively large mammalian and avian predator populations. Unfortunately, managers did not quantify relative predator populations or species-specific direct effects of predator control on avian recruitment.

The USFWS Call-count Survey did not begin until 1966 and does not include the Gray Lodge area; therefore, information on dove populations in California during the early study period are not available for interpretation relative to the higher recruitment values recorded then. Additionally, recruitment information from relatively small areas, especially areas managed specifically for wildlife, do not necessarily reflect changes in Call-count Survey trends, because doves are widespread and use many habitats (Sayre and Silvy 1993). We note, too, that the California dove population index declined between the 1970s and the 1990s (Dolton and Smith 1999), a trend opposite that which would have been predicted based on weather and production differences we found at Gray Lodge between the middle and late periods. Considering survival estimates generated nationwide during 1964–74 (Tomlinson et al. 1988), only in 1980 did fledglings produced/active pair (2.4) at Gray Lodge fall below the estimated 2.5 needed to maintain populations in California. Therefore, if poor recruitment has contributed to the decline of California doves, Gray Lodge (or riparian habitat in general) may not be representative of that trend, at least consistently, because in all years in the 1990's, fledgling production/active pair was at least twice the minimum needed (and it was 1.4 times the minimum in 1979). We emphasize that this conclusion is based on survival estimates that are dated, however.

We hypothesize that causes other than recruitment may better explain the general decline of doves in California, and these should be examined. Of special consideration would be the effects of broad scale alterations of nesting and foraging habitats (e.g., Katibah 1984, Olson et al. 1991, Reeves et al. 1993, Tomlinson et al. 1994, Ostrand et al. 1998). For example, the extent of riparian habitats has declined about 97% in California since settlement (Katibah 1984), but foothill woodlands (Bolsinger 1988) and certain orchards (Loomis 1983) continue to be abundant and productive of doves (Miller et al. 2001). Historical dove nesting data from orchards and oak woodlands were insufficient for our analysis, so we did not include them; but production in the 1990s in these habitats was more than adequate to balance mortality (Miller et al. 2001). This suggests that breeding population trends may result less from recruitment rates than from the total extent of dove nesting habitats available.

As attractive as historical analyses are, more efficient and useful analyses could be conducted with predictable data. For example, managers could begin an annual wing-collection survey to monitor mourning dove harvest age ratios to index productivity. Ultimately, long-term comparisons of recruitment rates could be made without resorting to historical data. We also recommend that managers initiate large-

scale banding programs to update survival estimates and facilitate annual comparisons of productivity vs. mortality to provide another data set for long-term trend analyses to accompany the Call-count indices.

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LITERATURE CITED

Bolsinger, C.L. 1988. The hardwoods of California's timberlands, woodlands, and savannas. U.S. Forest Service Resource Bulletin PNW-RB-148.

Cloyd, L.H. 1999. The evolution of waterfowl refuges and the early years of the Gray Lodge Wildlife Area. Outdoor California 60(1):18-22.

Cowan, J.B. 1952. Life history and productivity of a population of western mourning doves in California. California Fish and Game 38:505-521.

Fichter, E. 1959. Mourning dove production in four Idaho orchards and some possible implications. Journal of Wildlife Management 23:438-447.

Geissler, P.H., D.D. Dolton, R. Field, R.A. Coon, H.F. Percival, D.W. Hayne, L.D. Soileau, R.R. George, J.H. Dunks, and S.D. Bunnell. 1987. Mourning dove nesting: seasonal patterns and effects of September hunting. U.S. Fish and Wildlife Service, Resource Publication 168.

Green, R.E. 1989. Transformation of crude proportions of nests that are successful for comparison with Mayfield estimates of nest success. Ibis 131:305-307.

Green, R.F. 1977. Do more birds produce fewer young? A comment on Mayfield's measure of nest success. Wilson Bulletin 89:173-175.

Hitchcock, R.R., and R.E. Mirarchi. 1984. Duration of dependence of wild fledgling mourning doves upon parental care. Journal of Wildlife Management 48:99-108.

Johnson, D.H. 1991. Further comments on estimating nest success. Ibis 133:205-207.

Katibah, E.F. 1984. A brief history of riparian forests in the Central Valley of California. Pages 23-29 *in* R.E. Warner and K.M. Hendrix, editors. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley, California, USA.

Loomis, R.S. 1983. An ecological overview. Pages 389-404 *in* A.F. Scheuring, editor. A guidebook to California agriculture. University of California Press, Berkeley, California, USA.

Lowe, J.I. 1956. Breeding density and productivity of mourning doves on a county-wide basis in Georgia. Journal of Wildlife Management 20:428-433.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bulletin 73:255-261.

_____. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456-466.

McClure, H.E. 1950. An eleven-year summary of mourning dove observations in the West. Transactions of the North American Wildlife Conference 15:335-346.

Miller, M.R., C.L. Stemler, and D.S. Blankenship. 2001. Mourning dove productivity in California during 1992-95: was it high enough to balance mortality? Journal of Wildlife Management 65:300-311.

National Oceanic and Atmospheric Administration. 1949-50, 1979-80, 1992-95. Climatological Data -- California. National Climatic Data Center, Asheville, North Carolina, USA.

Olson, T.E., C.E. Braun, and R.A. Ryder. 1991. Agricultural land use and mourning doves in eastern Colorado: implications for nesting and production in the Great Plains. Prairie Naturalist 23:1-10.

Ostrand, W.D., P.M. Meyers, J.A. Bissonette, and M.R. Conover. 1998. Changes in land use as a possible factor in mourning dove population decline in central Utah. Journal of Field Ornithology 69:192-200.

Reeves, H.M., R.E. Tomlinson, and J.C. Bartonek. 1993. Population characteristics and trends in the western management unit. Pages 341-376 *in* T.S. Baskett, M.W. Sayre, R.E. Tomlinson, and R.E. Mirarchi, editors. Ecology and management of the mourning dove. Stackpole Books, Harrisburg, Pennsylvania, USA.

SAS Institute. 1989. SAS/STAT user's guide, version 6, fourth edition. SAS Institute, Cary, North Carolina, USA.

Sauer, J.R., and B.K. Williams. 1989. Generalized procedures for testing hypotheses about survival or recovery rates. Journal of Wildlife Management 53:137-147.

Sayre, M.W., and N.J. Silvy. 1993. Nesting and production. Pages 81-104 *in* T.S. Baskett, M.W. Sayre, R.E. Tomlinson, and R.E. Mirarchi, editors. Ecology and management of the mourning dove. Stackpole Books, Harrisburg, Pennsylvania, USA.

Schroeder, M.H. 1970. Mourning dove production in a Kansas osage orange planting. Journal of Wildlife Management 34:344-348.

Tomlinson, R.E., D.D. Dolton, H.M. Reeves, J.D. Nichols, and L.A. McKibben. 1988. Migration, harvest, and population characteristics of mourning doves banded in the Western Management Unit, 1964-1977. U.S. Department of Interior, Fish and Wildlife Service, Fish and Wildlife Technical Report 13, Washington, D.C., USA.

Tomlinson, R.E., D.D. Dolton, R.R. George, and R.E. Mirarchi. 1994. Mourning dove. Pages 5-26 *in* T.C. Tacha, and C.E. Braun, editors. Migratory shore and upland game bird management in North America. International Association of Fish and Wildlife Agencies, Washington, D.C., USA.

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DIET OF JUVENILE FALL-RUN CHINOOK SALMON IN THE LOWER MOKELUMNE RIVER, CALIFORNIA

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Gut contents of juvenile fall-run chinook salmon, *Oncorhynchus tshawytscha*, were collected on the lower Mokelumne River from January through June 1997 and 1998. Chinook salmon fed primarily on zooplankton and supplemented their diets with chironomid larvae and pupae and larval Sacramento suckers, *Catostomus occidentalis*, as they became available. The lower Mokelumne River experienced flood flows during the 1997 study period and elevated flows twice during the 1998 study period. These flows may have been responsible for the high percentage of zooplankton in the diets of these fish. Mean prey size was significantly related to fish length and sample year. However, the calculated index of fullness suggests that no significant difference in feeding activity occurred between the 2 water years.

INTRODUCTION

The Mokelumne River is a major tributary to the Sacramento-San Joaquin Delta. The regulated portion of the Mokelumne River below Camanche Dam is the subject of numerous proposed and implemented resource projects that affect fishes in this portion of the river. These projects include expansion of hatchery chinook salmon, *Oncorhynchus tshawytscha*, and steelhead, *O. mykiss*, production; improved fish passage at water diversions; salmonid spawning gravel enhancement projects; and possible water conveyance plans in the delta portion of the river. Several of these projects are specifically aimed at restoration of chinook salmon populations while impacts from other proposals are not clear. Changes in fish community structure, composition, and density resulting from such projects may have significant effects on the feeding ecology of fishes (Berg and Jorgensen 1991, Flecker 1992, Vetsler 1992, Baldwin et al. 2000). Furthermore, direct manipulation of habitat structure may affect habitat production, carrying capacity, and feeding rates of local fish populations (Shepherd et al. 1992, Mundie and Crabtree 1997, Maki-Petays et al. 2000). Understanding these processes is important in the evaluation of these projects. The main objectives of this study were to assess the relationships of fish size, river temperature, and flow, on prey size, feeding activity, and importance of zooplankton in the diets of lower Mokelumne River (LMR) juvenile chinook salmon in 1997 and 1998.

STUDY SITE

The LMR is an approximate 54-km reach of regulated river between Camanche Dam and its confluence with the Sacramento-San Joaquin Delta. The study area, between Camanche Dam and Lake Lodi, is characterized by alternating bar complex and flatwater habitats, with a gradient of approximately 0.17 m/km (Fig. 1). The drainage area below Camanche Dam consists of 87 km^2 of mostly agricultural and urbanized land (Anderson et al.[1] 1993). Several small streams and storm drains enter the lower river. Lake Lodi supplies a gravity-fed agricultural irrigation system and is annually filled from April through October. At least 34 fish species have been observed in the LMR since monitoring began in 1996 (Merz and Workman [2] 1998). Among the most abundant species, in addition to chinook salmon, are prickly sculpin, *Cottus asper*; Sacramento sucker, *Catostomus occidentalis*; and steelhead.

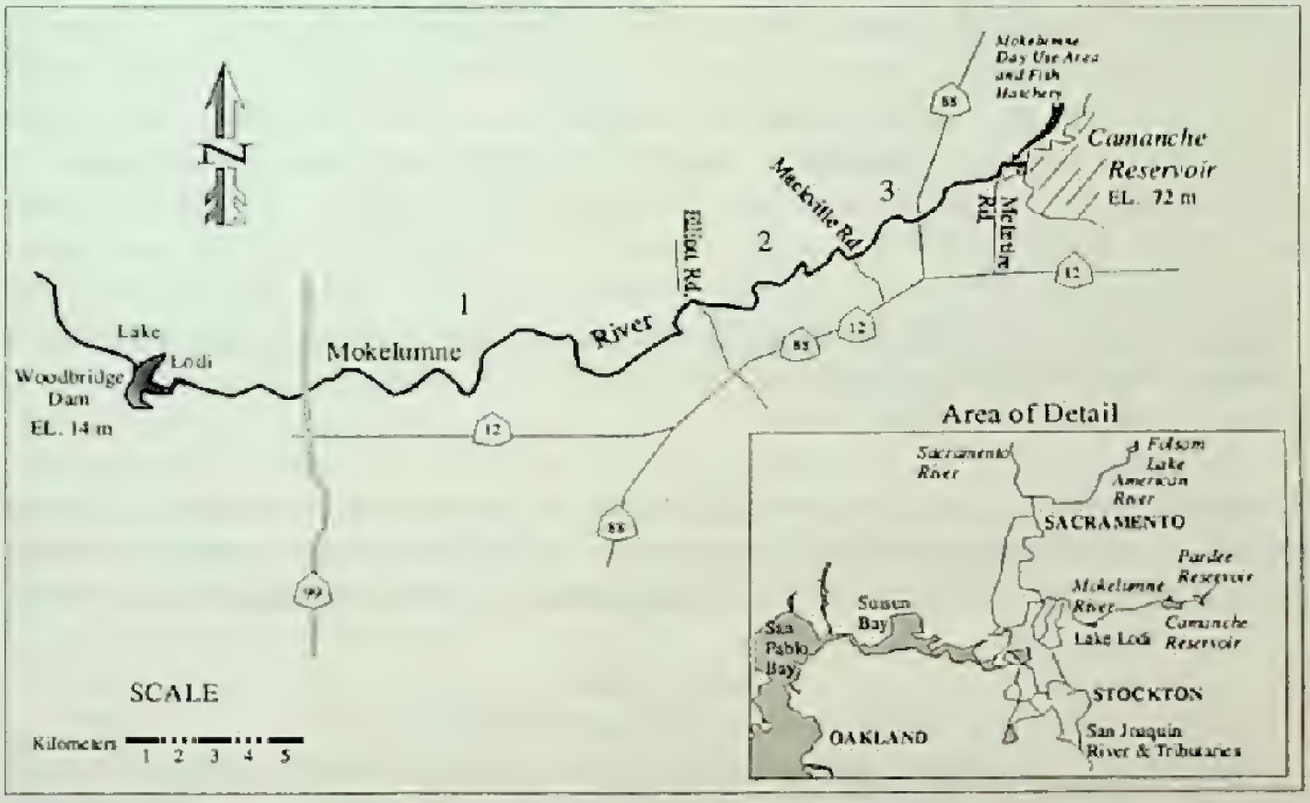

Figure 1. The lower Mokelumne River between Camanche Dam and Woodbridge Dam, San Joaquin County, California. The three reaches of river designated for this study are indicated.

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[1] Anderson, S.W., T.C. Hunter, E.B. Hoffman, and J.R. Mullen. 1993. Water resources data California water year 1992. Volume 3. Southern Central Valley Basins and the Great Basin from Walker River to Truckee River. U.S. Geological Survey Water-Data Report CA-92-3. U. S. Geological Survey, Sacramento, California, USA.

[2] Merz, J.E., and M. Workman. 1998. Lower Mokelumne River Fish Community Survey. East Bay Municipal Utility District, Lodi, California, USA

Daily discharge from Camanche Dam into the LMR ranged from 142 m^3/s (Camanche spill conditions) on 3 January 1997 to 13 m^3/s on 1 July 1997 (Fig. 2). Flows during 1998 remained elevated from the beginning of February through June, peaking at 99.2 m^3/s in February and again in June.

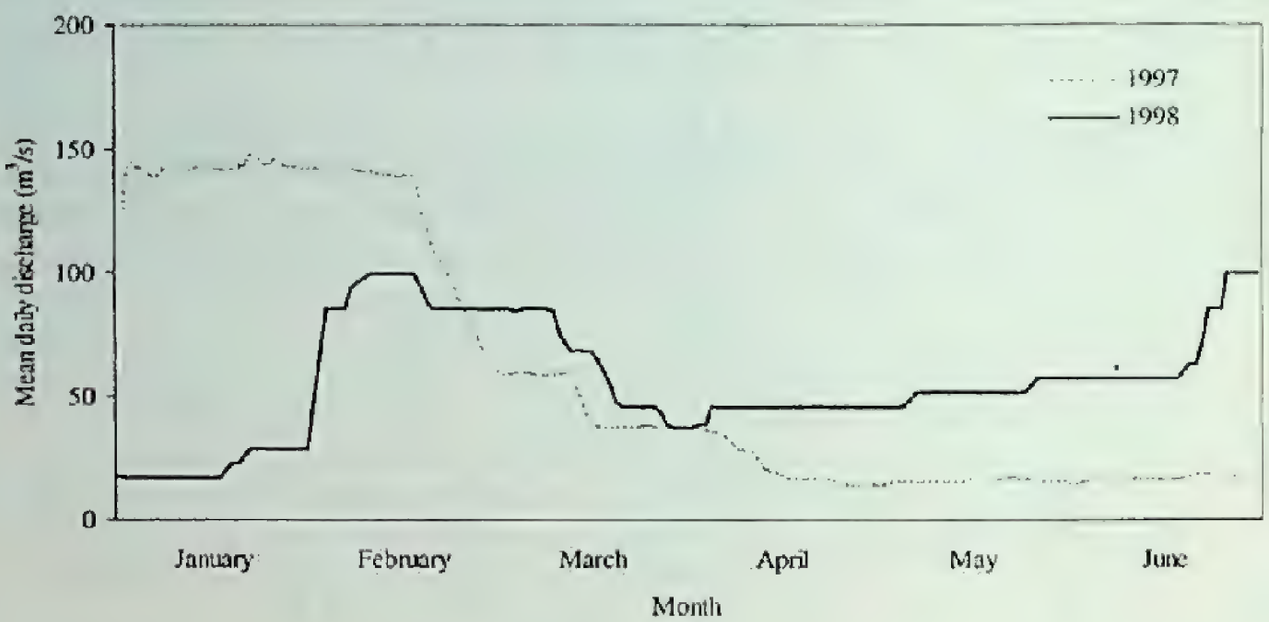

Figure 2. Mean daily discharge from Camanche Dam into the lower Mokelumne River from 1 January to 30 June 1997 and 1998.

Water temperatures in 1997 ranged from 9.4°C in January at Camanche Dam to 15.6°C in June in a small backwater at Highway 99. Water temperatures in 1998 ranged from 10.0°C in February at Camanche Dam to 15.0°C in June at Highway 99.

METHODS

The Mokelumne River above Lake Lodi was separated into 3 reaches based on stream gradient and substrate characteristics (Fig. 1). Habitat types were identified and assigned to 1 of 5 habitats (modified from Bisson et al. 1981): 1) channel pools (unbroken surface, slow velocity, deep water), 2) glides (moderately shallow water with an even flow that lacked pronounced turbulence), 3) runs (rippled surface, fast velocity, shallow water), 4) riffles (streambed substrate protruding through water surface), and 5) off-channel pools (slow, deep water adjacent but contiguous to the main channel).

Juvenile chinook salmon were sampled between Lake Lodi and Camanche Dam during monthly fish-community surveys. Sampling was performed for 3 days the 2nd week of each month from January through July 1997 and 1998. Sampling occurred

between 0900 and 1500 hr with a 15 x 2- m bag seine with 1.6 mm mesh in all habitat types within each reach in an effort to representatively sample the river. To reduce the take of chinook salmon, minimum monthly target sample size was at least 12 fish based on preliminary stomach analysis (see Hurtubia 1973).

Specimens were immediately preserved in an 80-85% ethyl-alcohol solution, packed in ice, and transported to the laboratory for analysis. The fork length (FL) of each fish was measured to the nearest mm and stomach contents were removed. Contents were hand-sorted in the lab under a dissecting microscope and magnifying illuminator. Food items were identified to family for aquatic organisms and order for terrestrial organisms; life stages (larva, pupa, or adult) were determined. Adult Ephemeroptera, Trichoptera, and Diptera were classified as terrestrial. Food items were also categorized into the following maximum length size classes: class 1 = <2mm; class 2 = 2-7 mm; class 3 = 8-13 mm; class 4 = 14-20 mm; class 5 = >20 mm (Baldridge et al.[3] 1987). Prey lengths were then estimated using the mean length for each size class.

Because most food items removed from fish stomachs were disarticulated or partly digested, representative samples of whole prey items from benthic and drift samples (Merz[4] 1997) were used to estimate dry biomass of stomach contents by oven drying selected samples of each taxon at 70°C for 24 hours to constant weight and then weighing the samples (Bowen 1983). As many of these organisms were extremely small (< 0.0001 g), groups of 20-50 organisms of a particular taxon from each size class were dried, depending on how many could be obtained. Mean weight was calculated for the taxon, life stage, and size class by dividing the dry weight of the group by the number of individuals. Mean weight was multiplied by number of the same taxon found in fish stomachs. Dry-weight sums were used to estimate monthly diet composition of juvenile chinook salmon following the methods of Johnson and Johnson (1981). Diet was pooled on a monthly basis and analyzed by frequency of occurrence, numeric, and gravimetric (dry weight) methods (Bowen 1983). To assess the relative importance of food items, an index of relative importance (IRI) (Hyslop 1980) was calculated for each food category:

$$IRI = (\%N + \%W) \times \%O,$$

where,

%N = a food item's percentage of the total number of organisms ingested,
%W = a food item's percentage of the total weight of food ingested, and
%O = a food item's percentage frequency of occurrence in all stomachs that contained food.

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[3] Baldridge, J.E., T.K. Studley, T.P. Keegan and R.F. Franklin. 1987. Response of fish populations to altered flows project. Study Plan. Entrix, Inc. Walnut Creek, California, USA.

[4] Merz, J.E. 1997. An evaluation of spawning gravel enhancement projects in the lower Mokelumne River, California. Mimeo Report, East Bay Municipal Utility District, Fisheries and Wildlife Division, Lodi, California, USA.

To make dietary comparisons, IRI values of each food item were converted to percentages based on total IRIs for each month (Merz and Vanicek 1996).

An overall index of fullness (IF) for each monthly sample was calculated by dividing the mean weight of stomach contents for that month by mean FL of all chinook salmon examined that contained food and multiplying this value by 100 (Merz and Vanicek 1996).

Statistical Methods

A paired t-test was used to compare mean daily river flow and water temperatures immediately below Camanche Reservoir between years (Zar 1996). A Wilcoxon paired signed-rank test was used to compare monthly mean indices of fullness between years (Sall et al. 2001). Estimated mean prey length was compared to chinook salmon FL and sample year using the JMP linear regression model function, which performs an analysis of variance (ANOVA) (Sall et al. 2001). ANOVA was also used to compare mean monthly IF to mean river flows and temperature from each sampling week and monthly zooplankton IRI to river flow. A significance level of 0.05 was used in statistical tests.

RESULTS

Mean daily releases from Camanche Dam were not significantly different between years ($t = 1.05$, df = 180, $P = 0.29$) (Fig. 2). However, mean daily water temperatures released from Camanche Dam were significantly cooler in 1997 than 1998 ($t = -13.7$, df = 180, $P < 0.001$) (Fig. 3). Stomachs from 158 juvenile chinook salmon in 1997 and 180 salmon in 1998 were examined. Juvenile chinook salmon first appeared in the Mokelumne River Day-Use Area (Fig. 1) in mid-December 1996 and 1997. Sufficient numbers of fish for diet analysis were not captured until February in 1997 and January in 1998 (Table 1). Greatest numbers of juveniles were captured during March in 1997 and during February in 1998 (Table 1). Almost all chinook salmon juveniles were gone from the Mokelumne River above Lake Lodi by the end of June in both years. Mean FL varied from 40 mm in February to 87 mm in May of 1997 and from 38 mm in January to 86 mm in June of 1998 (Table 2).

Diet Composition

Juvenile fall-run chinook salmon consumed a variety of prey types, but most of their diet was composed of only a few taxa of aquatic organisms. Major food items were zooplankton (daphniids and cyclopids), chironomid larvae and pupae, and Sacramento sucker larvae (Table 3). Trichoptera larvae and pupae (Hydropsychidae and Hydroptilidae) were important in May 1997 and January 1998 (Fig. 4). Juvenile chinook salmon relied heavily on zooplankton, primarily *Daphnia pulex* (Cladocera), and chironomid larvae and pupae throughout their rearing period in the LMR above Lake Lodi, but added Sacramento sucker larvae as an important diet component in

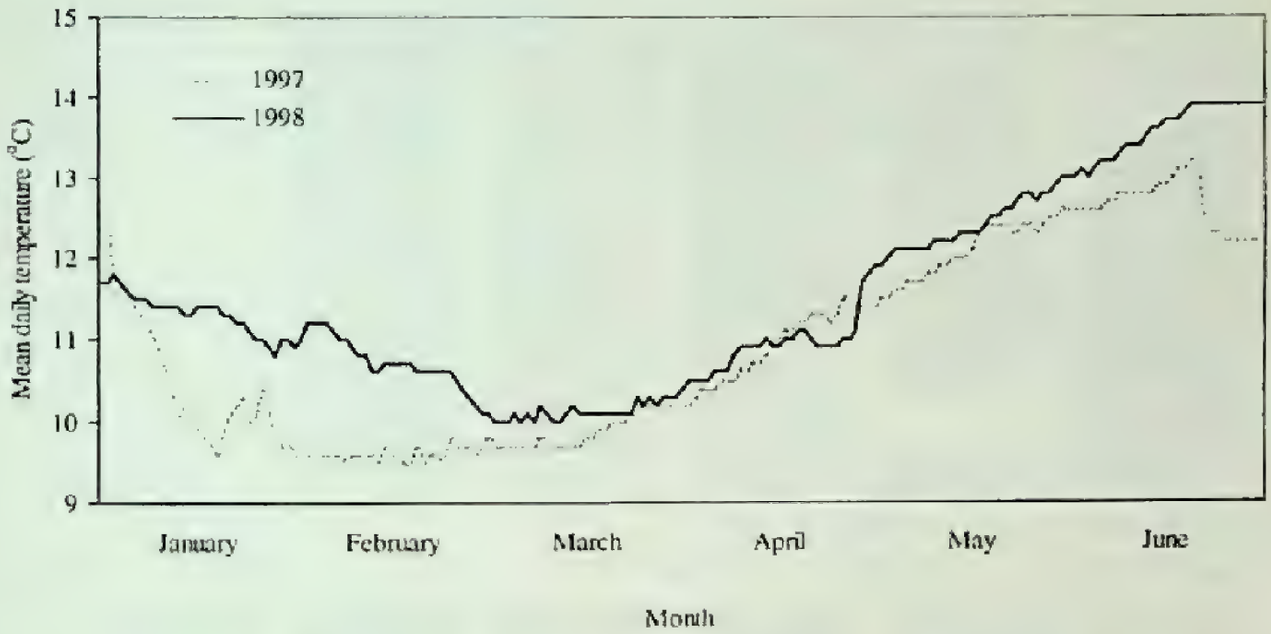

Figure 3. Lower Mokelumne River mean daily temperature measured directly below Camanche Dam from 1 January to 30 June 1997 and 1998.

Table 1. Number of juvenile chinook salmon captured by seine and the number sampled for stomach contents (in parenthesis) in the lower Mokelumne River by reach (see Fig. 1) and sampling period, 1997 and 1998.

1997

Reach	January	February	March	April	May	June
1		14 (2)	160 (29)	138 (14)	10 (2)	6 (3)
2	6	186 (12)	24 (5)	82 (5)	41(10)	11(6)
3	3	17 (4)	160 (30)	104 (10)	165 (24)	5 (3)
Total	9	217 (18)	344 (64)	324 (29)	216 (36)	22 (12)

1998

	January	February	March	April	May	June
1	468 (20)	211(20)	50 (10)	33 (10)	9 (9)	6 (6)
2	106 (12)	20 (5)	4 (1)	1 (0)	7 (7)	7 (7)
3	24 (5)	434 (30)	60 (14)	87 (15)	6 (6)	3 (3)
Total	598 (37)	665 (55)	114 (25)	121 (25)	22 (22)	16 (16)

Table 2. Monthly sample size, mean FL (mm) and percent sac-fry* of juvenile chinook salmon sampled for diets from the lower Mokelumne River, 1997 and 1998.

Year	January	February	March	April	May	June
1997						
Sample size		18	64	29	36	12
Mean FL (SD)		40(4.1)	43(1.3)	52(17.6)	87(16.8)	83(2.8)
% sac fry		11	6	3	0	0
1998						
Sample size	37	55	25	25	22	16
Mean FL (SD)	38(8.3)	40(4.7)	47(7.2)	58(14.3)	76(13.2)	86(6.1)
% sac fry	22	11	8	0	0	0

* newly hatched salmon before absorption of the yolk sac.

Table 3. Major prey of juvenile chinook salmon in the lower Mokelumne River, 1997-1998. %O = percent frequency of occurance, %N = percent of the total number, %W = percent wieght, and %IRI = percent Index of Relative Importance.

Prey item	1997				1998			
	%O	%N	%W	%IRI	%O	%N	%W	%IRI
Daphniidae	62	42	0	49	58	66	2	76
Cyclopidae	26	8	0	4	1	0	0	0
Chironomidae larvae	21	3	0	1	26	5	3	1
Chironomidae pupae	54	41	2	38	67	21	14	16
Fish larvae	5	1	94	8	7	0	77	6
Other	13	6	3	1	13	8	5	1

late spring (Fig. 4). Less common prey included corixids; baetid, ephemerellid, and tricorythid mayflies; oligochaetes; perlodid stoneflies; and terrestrial Hymenoptera.

In 1997, 85% of zooplankton observed in stomachs was *D. pulex*; the rest were Copepoda, Hydracarina, and other species of Cladocera. *D. pulex* was even more prominent in the diet in 1998, when it made up 98% of zooplankton observed in chinook salmon stomachs.

Feeding Relative to Prey Size

The estimated mean prey length found in sampled juvenile chinook salmon was 1.5 mm (SD = 0.5) in 1997 and 2.3 mm (SD = 1.1) in 1998. Mean prey-length

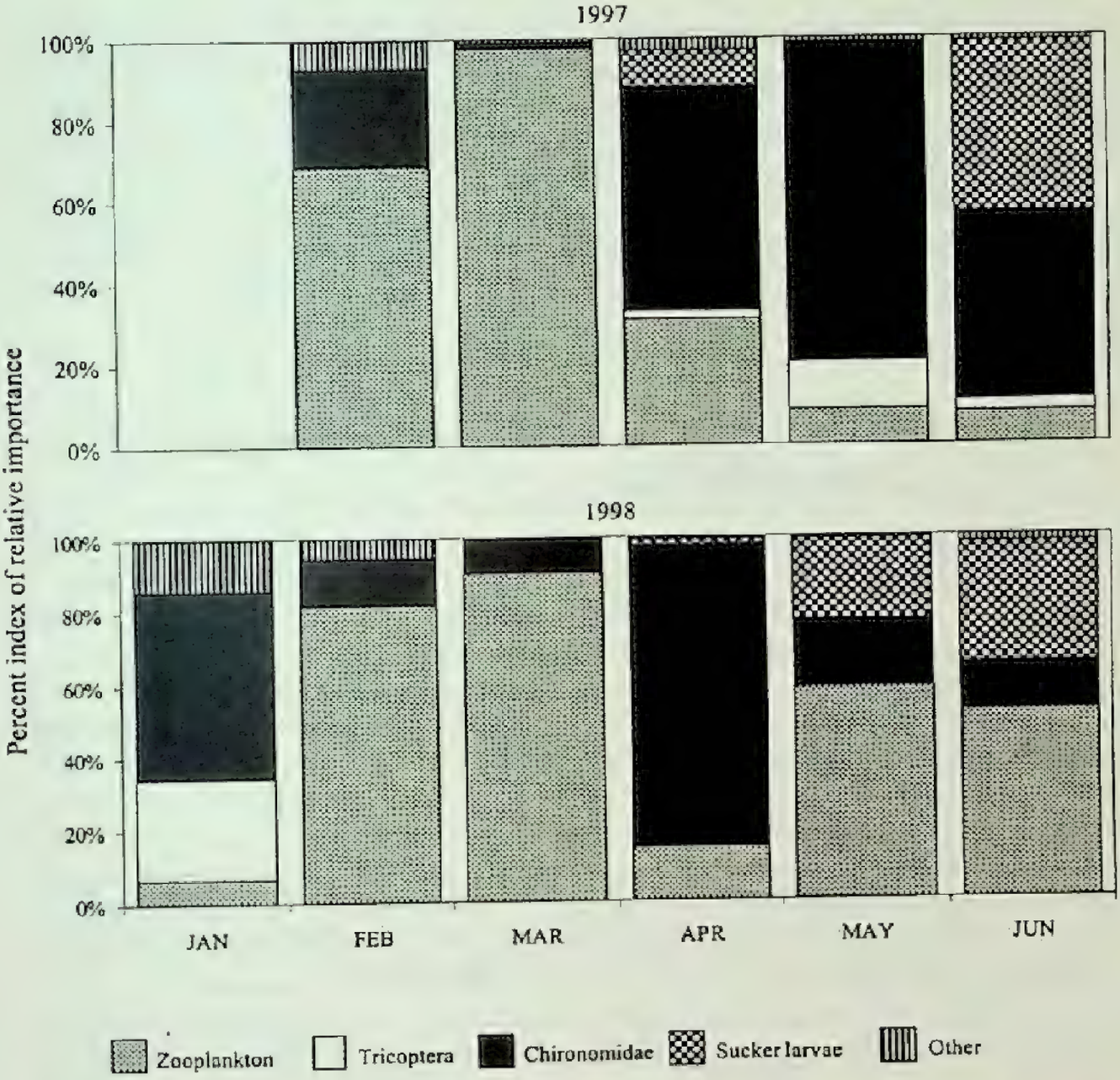

Figure 4. Percent index of relative importance (%IRI) for food of juvenile fall chinook salmon in the lower Mokelumne River by month, 1997 and 1998.

category was significantly related to chinook salmon FL and sample year ($F = 46.5$; $df = 2, 115$; $P<0.0001$) (Fig. 5). Prey size increased with fish length in both years and was larger in 1998 than 1997.

Feeding Activity

Temporal patterns of chinook salmon feeding, as indicated by occurrence of empty stomachs and quantity of food in stomachs, varied little between years. Only 1 of 61 sac-fry observed over both years had an empty stomach, suggesting that fry began exogenous feeding before completely absorbing the yolk sac. No fish with empty stomachs were collected in 1997 and only 4 of 180 (2%) in 1998 (Table 4). Feeding activity, as indicated by the IF, was not significantly different between the 2 years

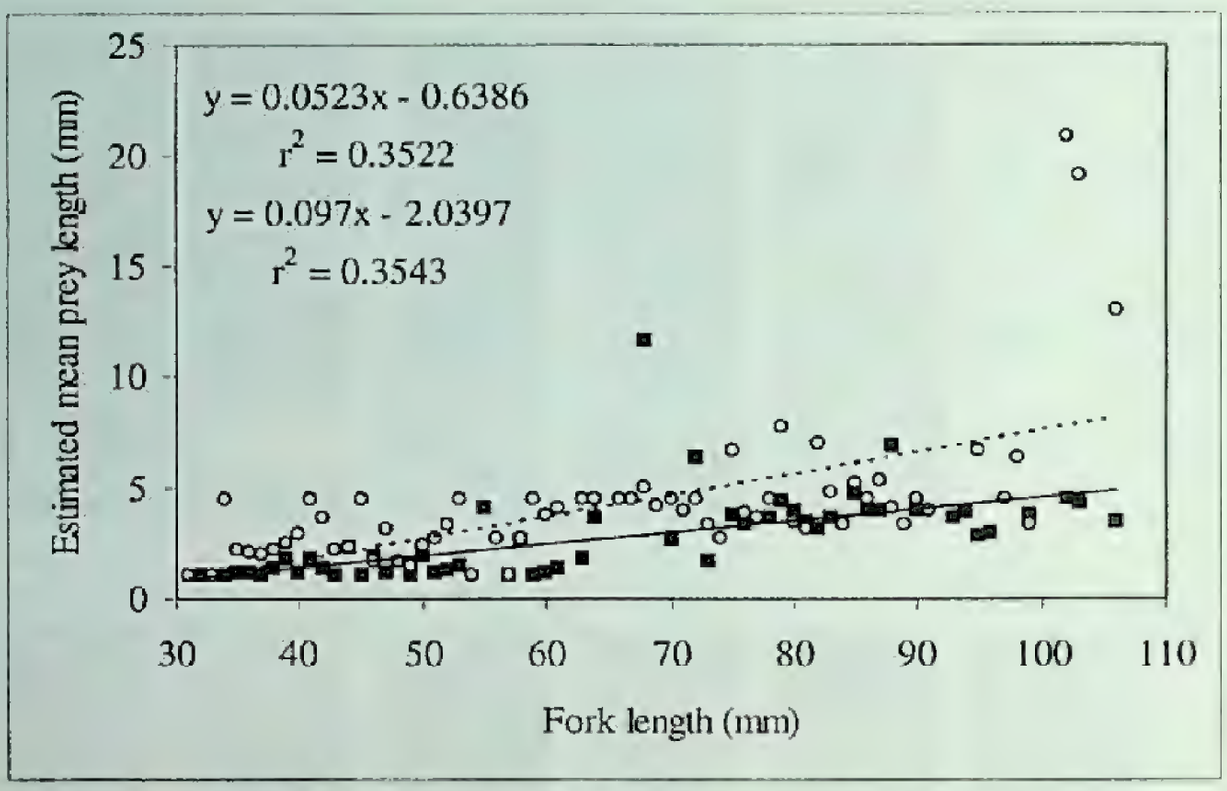

Figure 5. The relationship between lower Mokelumne River juvenile chinook salmon FL and estimated mean prey length in 1997 and 1998. Regression equations for simple linear regression are indicated for 1997 and 1998.

Table 4. Frequency of empty stomachs and index of fullness (IF) by month for juvenile chinook salmon in the lower Mokelumne River, 1997 and 1998. Number in parenthesis indicates the number of individuals with stomachs containing food.

	1997		1998	
Month	%Empty stomachs	IF	%Empty stomachs	IF
January			8(37)	0.005
February	0(18)	0.001	0(55)	0.002
March	0(64)	0.003	4(25)	0.001
April	0(29)	0.070	0(25)	0.069
May	0(36)	0.102	0(22)	0.824
June	0(12)	1.436	0(16)	0.965
Mean (SD)		0.32(0.56)		0.32(0.42)

(W= -0.05; df = 4; $P = 0.56$). Mean IF for each week sampled was not significantly related to mean weekly flow ($r^2 = 0.10$; F = 1.05; df = 1, 9; $P = 0.33$). In contrast, mean IF for each week sampled was related to mean water temperature below Camanche Dam in 1997 ($r^2 = 0.67$; F = 18.35; df = 1, 9; $P = 0.002$) and 1998 ($r^2 = 0.81$; F = 27.20; df = 1, 4; $P = 0.01$). The high IF in June of both years resulted from increased consumption of Sacramento sucker larvae. Zooplankton IRI values for each week sampled were significantly positively related to flow ($r^2 = 0.56$; F = 11.24; df = 1, 9; $P = 0.009$).

DISCUSSION

Other researchers have found that riverine juvenile chinook salmon mainly consume immature stages of aquatic insects (Shapovalov and Taft 1954, Moyle 1976, Sagar and Glova 1988, Power 1992, Merz and Vanicek 1996). According to Sasaki (1966), only 16% of insects consumed by emigrating chinook salmon in the lower Sacramento-San Joaquin system were chironomids. In contrast, over 90% of the insects consumed by chinook salmon in LMR were chironomids.

Several reports also discuss the importance of zooplankton in the diets of juvenile chinook salmon, but this is most common in estuaries, lagoons, and reservoirs (Allen and Hassler[5] 1986, Rondorf et al. 1990, Busby and Barnhart 1995). However, in February and March of 1997 and 1998, zooplankton provided over 70% of the IRI for diets of LMR juvenile chinook salmon (Fig. 4), in an area approximately 20 km upstream of tidal influence and 50 km above saltwater intrusion. The predominance of *D. pulex* in the diet is most likely due to the large number of fry captured in January and February of 1998 (Table 1). After reduction in zooplankton in the diets of juvenile chinook salmon, chironomids, primarily pupae, and Sacramento sucker larvae predominated stomach contents (Fig. 4). Chironomids and larval Sacramento suckers are often found in high numbers in the drift (Waters 1972, Merz[6] 1993). This suggests that juvenile chinook salmon in the lower Mokelumne River during 1997 and 1998 fed primarily on drift organisms.

Fish diet is greatly affected by the relative size of the fish to its prey (Zaret and Rand 1971, Johnson and Ringler 1980, Bowen 1983). In both years, a positive relationship between juvenile salmon FL and mean prey size was observed (Fig. 5).

River flow and time of year may also influence the diet of juvenile chinook salmon by altering prey availability. High water levels and low temperatures probably were responsible for the relatively simple chinook salmon diets observed early in February

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[5] Allen, M.A. and T.J. Hassler. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest), chinook salmon. USDI Fish and Wildlife Service, Biological Report 82(11.49).

[6] Merz, J. E. 1993. A survey of drift and benthic communities and their use in the diet of the more abundant fish species in the lower American River, February - July, 1992. California State University, Sacramento, Foundation Contract Report FG1353.

and March of 1997 and most of 1998. Dramatic changes and fluctuations in stream velocities affect benthic and drift organisms (Franklin and Pearson 1968, Fisher and LaVoy 1972, Ward 1976, Petts 1984) and alter their availability to predators. Camanche Dam reached flood-stage release (142 m^3/s) well before the majority of juvenile chinook emerged in 1997 (Fig. 2). Plankton tows in Camanche Reservoir along the dam face in spring 1996 showed dense populations of daphniids and cyclopids in the water column (Merz[7] 1997). These organisms may have been dispersed throughout the LMR during high flow conditions in both 1997 and 1998. The relationship between zooplankton IRI values and river flow was strong in both years, but statistically significant only in 1998. This suggests flow magnitude influenced zooplankton consumption by juvenile chinook salmon in the LMR (Fig. 2 and 4). Thus, juvenile chinook salmon relied heavily on zooplankton early in the 1997 season and began consuming chironomids and larval suckers as the salmon grew and these prey items increased in availability later in the season. Conversely, lower flows during January of 1998 may have provided juvenile chinook salmon greater opportunity to forage on chironomid larvae and pupae, Trichoptera and other aquatic and terrestrial organisms (Fig. 2 and 4).

In summary, it appears that 3 factors affected juvenile chinook salmon feeding habits in the LMR in 1997 and 1998. First, high flows probably influenced the availability of prey, so that, at high flows, zooplankton (probably from Camanche Reservoir) predominated the diet. As flows decreased, other prey items in the drift became available and were more important in the diet. Second, prey size increased as the juvenile salmon grew. Finally, feeding rate, as indicated by the IF, increased as water temperature increased. The importance of each of these factors is confounded by temporal trends and the fact that they frequently co-vary. As both 1997 and 1998 were years of higher-than-normal precipitation and flow, future dietary investigations should be conducted during more varied flow regimes and in conjunction with drift and benthic sampling. This may better explain the mechanisms influencing juvenile chinook salmon feeding behavior in the LMR.

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[7] Merz, J.E. 1997. A survey of zooplankton along the face of Camanche Dam, Spring 1996. Mimeo Report, East Bay Municipal Utility District, Fisheries and Wildlife Division, Lodi, California, USA.

LITERATURE CITED

Baldwin, C.M., D.A. Beauchamp, and J.J. Van Tassell. 2000. Bioenergetic assessment of temporal food supply and consumption demand by salmonids in the Strawberry Reservoir food web. Transactions of the American Fisheries Society 129:429-450.

Berg, S. and J. Jorgensen. 1991. Stocking experiments with 0-plus and 1-plus trout parr, Salmo trutta L., of wild and hatchery origin: I. Post-stocking mortality and smolt yield. Journal of Fish Biology 39:151-170.

Bisson, P.A., J.L. Nielsen, R.A. Palmason, and L.E. Grove. 1981. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. Pages 62-73 *in*: N.B. Armantrout, editor. Symposium on acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Portland, Oregon, USA.

Bowen, S.H. 1983. Quantitative description of diet. Pages 325-336 *in*: L. A. Nielsen and D. L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland, USA.

Busby, M.S. and R.A. Barnhart. 1995. Potential food sources and feeding ecology of juvenile fall chinook salmon in California s Mattole River lagoon. California Fish and Game 81:133-146.

Fisher, S.G. and A. LaVoy. 1972. Differences in littoral fauna due to fluctuating water levels below a hydroelectric dam. Journal of the Fisheries Research Board of Canada 29:1472-1476.

Flecker, A.S. 1992. Fish trophic guilds and the structure of a tropical stream: weak direct vs. strong indirect effects. Ecology 73:927-940

Franklin, D. and W. Pearson. 1968. Some factors affecting drift rates of Baetis and Simuliidae in a large river. Ecology 49:75-81.

Hurtubia, J. 1973. Trophic diversity measurement in sympatric predatory species. Ecology 54:870-890.

Hyslop, E.J. 1980. Stomach contents analysis - a review of methods and their application. Journal of Fish Biology 17:441-429.

Johnson, J. and E. Johnson. 1981. Feeding periodicity and diet variation in diet composition of subyearling coho salmon, *Oncorynchus kisutch*, and steelhead, *Salmo gairdneri*, in a small stream during summer. Fishery Bulletin 79:381-376.

Johnson, J.H. and N.H. Ringler. 1980. Diets of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) relative to prey availability. Canadian Journal of Zoology 58:553-558.

Maki-Petays, A., T. Vehanen, and T. Muotka. 2000. Microhabitat use by age-0 brown trout and grayling: seasonal responses to streambed restoration under different flows. Transactions of the American Fisheries Society 129:771-781.

Merz, J.E. and C.D. Vanicek. 1996. Comparative feeding habits of juvenile chinook salmon, steelhead, and Sacramento squawfiish in the lower American River, California. California Fish and Game 82:149-159.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley, California, USA.

Mundie, J.H. and D.G. Crabtree. 1997. Effects on sediments and biota of cleaning a salmonid spawning channel. Fisheries Management and Ecology 4:111-126.

Petts, G.E. 1984. Impounded rivers. John Wiley & Sons, New York, New York, USA.

Power, G. 1992. Seasonal growth and diet of juvenile chinook salmon (*Oncorhynchus tschawytsha*) in demonstration channels and the main channel of the Waitaki River, New Zealand, 1982-1983. Ecology of Freshwater Fish 1992:12-25.

Rondorf, D.W., G.A. Gray, and R.B. Fairley. 1990. Feeding ecology of subyearling chinook salmon in riverine and reservoir habitats of the Columbia River. Transactions of the American Fisheries Society 119:16-24.

Sagar, P.M. and G.J. Glova. 1988. Diel feeding periodicity, daily ration and prey selection of a riverine population of juvenile chinook salmon, *Oncorhynchus tschawytscha* (Walbaum). Journal of Fish Biology 33:643-653.

Sall, J., A. Lehman, and L. Creighton. 2001. A guide to statistics and data analysis using JMP and JMP IN Software, 2nd edition. Duxbury, Pacific Grove, California, USA.

Sasaki, S. 1966. Distribution and food habits of king salmon, *Oncorhynchus tschawytscha*, and steelhead rainbow trout, *Salmo gairdneri*, in the Sacramento - San Joaquin Delta. California Department of Fish and Game Fish Bulletin 163:108-114.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri* gairdneri) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game Fish Bulletin 98.

Shepherd, A.R., R.M. Warwick, K.R. Clarke, and B.E. Brown. 1992. An analysis of fish community responses to coral mining in the Maldives. Environmental Biology of Fishes 33:367-380.

Vetsler, N.M. 1992. Changes in zooplankton community structure under the increasing numbers of red salmon in Lake Dalnee, Kamchatka peninsula. Ekologiya (Moscow) 6:56-61.

Walters, C. J. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology 1:1-16.

Ward, J. 1976. Effects of flow patterns below large dams on stream benthos: a review. Pages 235-253 *in*: J.F. Orsborn and C.H. Allman, editors. Instream flow needs, volume II. American Fisheries Society, Bethesda, Maryland, USA.

Waters, T. 1972. The drift of stream insects. Annual Review of Entomology 17:253-272.

Zar, J. H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA.

Zaret, T. M. and A. S. Rand. 1971. Competition in tropical stream fishes: support for the competitive exclusion principle. Ecology 52:336-342.

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USE OF A CAR ALARM SEQUENCE IN THE NORTHERN MOCKINGBIRD REPERTOIRE

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The use of anthropogenic-sourced sounds by northern mockingbirds, *Mimus polyglottos,* is not fully understood. Mockingbirds are noted for adding alien sounds to their repertoire, especially songs and calls of other birds (Howard 1974). Examples of anthropogenic-sourced sounds include creaking wheelbarrows, vacuum cleaners, and human whistles (Laskey 1944). Mockingbirds are also known to imitate mechanical sounds, frogs, and insects (Gill 1995).

Northern mockingbirds have extensive repertoires (Breitwisch and Whitesides 1987) and can learn over 400 song bouts in a single year (Derrickson 1987a). However, Derrickson (1987a) found that up to 57% of a mockingbird's repertoire occurred only once in a sampling period of singing behavior. In another study, Derrickson (1988) reported that 25% of the song types only occurred once among singing males over a two-year period. The mockingbirds sang these rare songs during courtship behaviors. Mockingbirds increase their repertoire with age, but some songs are used temporarily, while others are retained indefinitely (Laskey 1944).

There are two hypotheses that may explain the evolution behind repertoire size, song diversity, and interspecific mimicry: intrasexual selection (male-male competition for mates), and intersexual selection (females selecting males). Howard (1974) suggested that sexual selection influenced the size of mockingbird repertoires. Males with larger repertoires are better able to attract mates and exclude competitors from their territories with the use of interspecific mimicry (intrasexual selection, Howard 1974). Logan and Hyatt (1991) noted that in the spring unmated males sang more frequently than mated males, which correlated with mate attraction. Spring song may also be a territorial signal (Logan and Fulk 1984). Work by Logan (1983) and Breitwisch and Whitesides (1987) support the intersexual hypothesis for song function in mockingbirds, i.e., that songs vocalized during the breeding season function largely in male-female interactions. No consensus has been reached regarding the function and evolution of the extensive repertoires in mockingbirds (Derrickson 1988), however, the two hypotheses may not be mutually exclusive.

On the evening of 3 May 1999, a male northern mockingbird vocalized a mimicked car alarm sequence at Wasco, Kern County, California, USA (longitude W 119.3, latitude N 35.6). During the 10-minute period, the bird vocalized the car alarm sequence twice, but the sequence was not heard again. The sequence resembled a Viper® car alarm (Directed Electronics, Inc., Vista, California, USA). The vocalization consisted of sounds resembling a series of bells, buzzes, whistles, beeps, and sirens.

The mockingbird I observed was vocalizing during the waning gibbous moon (91% of the visible disk was illuminated, the full moon occurred on 30 April 1999. U.S. Naval

Observatory, 1999[1]). Singing at night is typical of unmated male mockingbirds and occurs regularly during full-moon periods (Derrickson 1988, Gill 1995).

Mimicry of anthropogenic-sourced sounds seems to play a small role in the functioning repertoire of northern mockingbirds. Mimicked calls of other birds are more common and are predominant in mockingbird vocal displays (Howard 1974). These commonly occurring song types fall within two dichotomies: flight versus non-flight and mate associating versus not associating (Derrickson 1987b). Anthropogenic-sourced sounds fall within the group reported in the literature as those expressed only once and then dropped. Therefore, it appears that anthropogenic-sourced calls are not successful in securing mates or territory. Derrickson (1987b) reported that rare songs occur prior to the arrival of a female in the territory (prefemale stage), courtship stage, and night singing. Anthropogenic-sourced calls may be experimental efforts by unmated individuals to secure mates, but the unsuccessful rate of accomplishing this goal results in dropping the calls after a few bouts. The use of the car alarm sequence may be an example of this behavior.

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LITERATURE CITED

Breitwisch, R. and G.H. Whitesides. 1987. Directionality of singing and non-singing behaviour of mated and unmated Northern Mockingbirds, *Mimus polyglottos*. Animal Behaviour 35:331-339.

Derrickson, K.C. 1987a. Yearly and situational changes in the estimate of repertoire size in Northern Mockingbirds (*Mimus polyglottos*). The Auk 104:198-207.

Derrickson, K.C. 1987b. Behavioral correlates of song types of the Northern Mockingbird (*Mimus polyglottos*). Ethology 74:21-32.

Derrickson, K.C. 1988. Variation in repertoire presentation in Northern Mockingbirds. The Condor 90:592-606.

Gill, F.B. 1995. Ornithology, second edition. W. H. Freeman and Co., New York, USA.

Howard, R.D. 1974. The influence of sexual selection and interspecific competition on mockingbird song (*Mimus polyglottos*). Evolution 28:428-438.

Laskey, A.R. 1944. A mockingbird acquires his song repertory. The Auk 61:211-219.

Logan, C.A. 1983. Reproductively dependent song cyclicity in mated male mockingbirds (*Mimus polyglottos*). The Auk 100:404-413.

Logan, C.A. and K.R. Fulk. 1984. Differential responding to spring and fall song in mockingbirds (*Mimus polyglottos*). Journal of Comparative Psychology 98:3-9.

Logan, C.A. and L.E. Hyatt. 1991. Mate attraction by autumnal song in the Northern Mockingbird (*Mimus polyglottos*). The Auk 108:429-432.

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[1] U.S. Naval Observatory. 1999. Astronomical Applications Department, Sun and Moon Data for One Day, Washington, D.C., USA.

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FIRST EASTERN PACIFIC RECORDS OF THE LONGFIN MAKO SHARK, *ISURUS PAUCUS*, GUITAR-MANDAY, 1966

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The longfin mako shark, *Isurus paucus*, Guitar-Manday 1966, is a poorly known lamnid species reported from several scattered locations throughout the central and western Pacific, North Atlantic, including the Gulf of Mexico, and western Indian Ocean (Compagno 2001, Garrick 1967, Killiam and Parsons 1986, Unpubl. data). There are no records of the longfin mako shark from the eastern Pacific although Compagno et al. (1995) suggest that it may occur in the central eastern Pacific, but without confirmation. The mako shark genus *Isurus* comprises two described species, the shortfin mako (*I. oxyrinchus*) and longfin mako (*I. paucus*), each with a cosmopolitan distribution. The shortfin mako is a very common, well-known, important fishery species in many parts of the world. The lesser-known longfin mako shark was recognized as a distinct species in 1966, based on several specimens caught in Cuban waters (Guitar-Manday 1966). It was subsequently described as *I. alatus* (Garrick 1967) from several specimens that had been caught in the central Pacific. Garrick's description of *I. alatus* was in press at the time of Guitar-Manday's published description of *I. paucus*, relegating the former name to junior synonym status. Here I report on the first confirmed records of the longfin mako shark from the eastern Pacific based on two specimens that were captured off southern California.

The first specimen, a female estimated to be between 3.3-3.6 m TL, was caught in 1988 approximately 6 miles southeast of Anacapa Island, Ventura County, California. This specimen was dressed and shipped to a Boston, Massachusetts, seafood buyer who recognized it as a longfin mako shark and returned it to the fishermen in California. The firm bodied flesh of the shortfin mako is highly desirable while that of the longfin is mushy and of poor quality. This specimen was eventually discarded, although a photograph of it was published by Kronman (2000). A second longfin mako was captured in 1990 approximately 10 miles north of Santa Barbara Island, Santa Barbara County, California by Mr. T. Athens, a commercial longline fishermen. This specimen, also a female, was estimated to be 3.0-3.3 m TL and weighed 300 kg (Figure 1). It was caught at a depth of about 30 m in water over 800 m deep. This specimen was brought to a seafood buyer in the Los Angeles area. The seafood buyer recognized it as a longfin mako based on its softer flesh and the darker body coloration. The fact that a local buyer recognized it as a longfin mako versus the abundant shortfin mako suggest that seafood

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Figure 1. Longfin mako shark, *Isurus paucus*, caught off Santa Barbara Island. Photograph by T. Athens.

buyers in southern California are somewhat familiar with this lesser-known species.

Numerous photographs of the intact specimen were taken prior to removal of the jaws which were saved and are currently in the private collection of Mr. T. Athens of Ventura, California. Tooth base, height, and jaw symphysis were measured (Table 1) for the Santa Barbara Island specimen which had a tooth count of 10-1-2-2-1-10/12-12. The longfin's teeth are generally broader based and slightly higher than that of similar-sized shortfin makos. Photographs of the Santa Barbara Island specimen (Figure 1), its jaws (Figure 2), and tooth measurements have been deposited in the fish collection of the Ichthyology Department at the California Academy of Sciences (CAS 214228).

The longfin mako has been described by Guitar-Manday (1966), Garrick (1967), and Compagno (2001). A review of its characteristics are as follows: An *Isurus* with a pectoral fin length equal to head length; pelvic fin anterior margins nearly equal to that of posterior margin; anal fin origin slightly posterior to insertion of second dorsal fin; teeth are broad-based and the cusps robust, with the medial four uppers being straight and not recurved; underside of snout and mouth area dusky colored. Characteristics distinguishing the longfin from the shortfin are given in Table 2.

The longfin makos reported here were caught in 1988 and 1990, both of which were non-El Nino years. This suggests that longfin makos may occur in southern California waters on a regular basis. Longfin mako sharks are oviphagous with litters of 2-8 (Castro et al. 1999). Maturity is attained at about 190 cm for males and 245 cm for females,

TABLE 1. Base and height measurement for each tooth on upper and lower right side of jaw for an estimated 3.0-3.3 m TL longfin mako. The length of the upper and lower right jaw symphysis, respectively, was 36.3 cm and 34.4 cm.

	Upper height:	Upper base:	Lower height:	Lower base:
Anterior:	39.0	28.5	20.0	38.0
Anterior:	44.0	28.5	26.0	41.0
Intermediate:	15.5	19.5	23.5	26.0
Posterior:	26.5	28.0	21.5	22.0
Posterior:	31.5	25.5	20.0	21.0
Posterior:	31.0	23.0	18.0	18.0
Posterior:	29.0	19.5	17.0	15.0
Posterior:	22.5	18.0	13.0	13.0
Posterior:	17.0	16.0	11.0	9.0
Posterior:	12.0	10.0	8.0	7.0
Posterior:	8.0	9.5	8.0	4.5
Posterior:	5.0	7.5	6.5	2.0
Posterior:	4.0	7.5	---	---

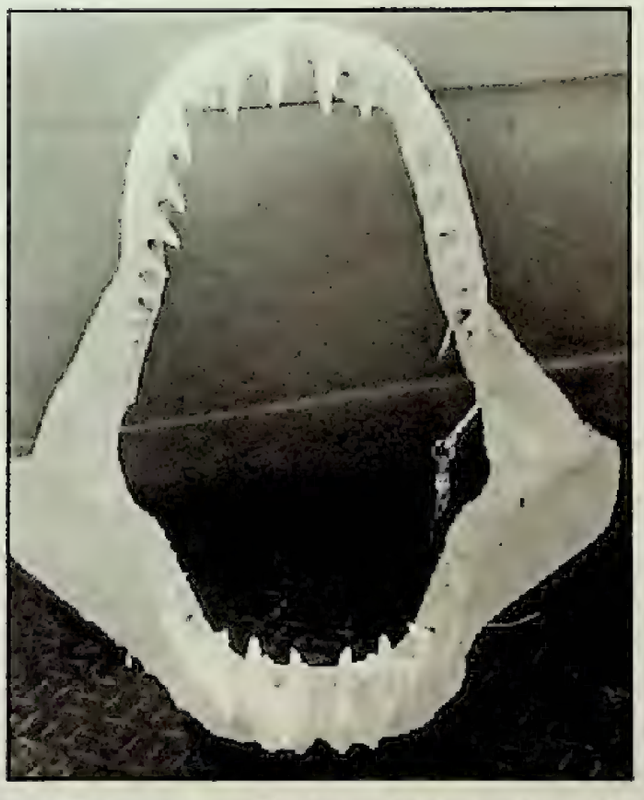

Figure 2. Jaws of the Santa Barbara Island longfin mako shark in Figure 1. Photograph by D. Ebert.

TABLE 2. A summary of characteristics distinguishing longfin from shortfin mako sharks.

Characteristic:	Longfin Mako	Shortfin Mako
1. Dorsal body coloration:	Dark blue to black above.	Brilliant blue above, becoming a lighter blue on its flanks.
2. Underside of mouth and snout:	Distinctly dusky, except in small juveniles.	White.
3. Body:	Relatively slender.	Robust compared to similar sized longfin mako's.
4. Snout:	Narrowly to bluntly pointed.	Acutely pointed.
5. Pectoral fins:	Length about equal to head length.	Length considerably less than head length.
6. Pelvic fin anterior margins:	Nearly equal to that of the posterior margins.	Length noticeably less than posterior margin.
7. Anal fin origin:	Slightly posterior to insertion of the second dorsal fin.	Under midbase of second dorsal fin.
8. Upper tooth base:	Noticeably broader than that of shortfin.	Noticeably narrower than that of longfin.
9. Anterior tooth cusp:	Broad, robust, less flexuous, and less oblique than in shortfin mako.	Narrow, slender, flexuous, and more oblique than in longfin mako.
10. Eye diameter:	Greater than 33% snout length.	Less than 33% snout length.

with a maximum size of 417 cm (Gilmore 1993, Joung et al. 1989). Longfin mako's feed mainly on schooling fishes and cephalopods (Compagno 2001). Its slender build and longer pectoral fins suggest that they are a less active shark than the shortfin mako (Compagno 2001). They appear to live in deeper water than the shortfin mako. Very little else is known about their biology.

The occurrence of the longfin mako shark brings to 40, the number of shark species that are now known to occur in California waters (Ebert, in press).

Key to mako sharks:

1a. Underside of snout and mouth area white; cusps of anterior teeth recurved forward; pectoral fins much shorter than head length; anal fin origin below second dorsal fin base.....Shortfin Mako Shark, *Isurus oxyrinchus*.

1b. Underside of snout and mouth area dusky; cusps of anterior teeth straight; pectoral fins about equal to head length; anal fin origin below or posterior to second dorsal fin insertion.....Longfin Mako Shark, *Isurus paucus*.

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LITERATURE CITED

Castro, J.I., C.M. Woodley, and R.B. Brudek. 1999. A preliminary evaluation of the status of shark species. FAO Fisheries Technical Paper. No. 380. Rome, FAO. 72 pp.

Compagno, L.J.V. 2001. Sharks of the World. Volume 2. Heterodontiformes, Lamniformes and Orectolobiformes. An annotated and illustrated catalogue of the shark species known to date. FAO Species Catalogue for Fisheries Purposes (1):1-269.

Compagno, L.J.V., F. Krupp, and W. Schneider. 1995. Tiburones. *In* W. Fischer, F. Krupp, W. Schneider, C. Sommer, K.E. Carpenter y V.H. Niem (eds.), Guia FAO para la identificacion de especies para los fines de la pesca. Pacifico Centro-Oriental. Food and Agriculture Organization of the United Nations, Rome, Vol. 2:645-741.

Ebert, D.A. In Press. Sharks and rays of California. University of California Press.

Garrick, J.A.F. 1967. Revision of sharks of genus *Isurus* with description of a new species (Galeoidea, Lamnidae). Proc. U.S. Nat. Mus., 118(3537):663-691.

Gilmore, R.G. 1993. Reproductive biology of lamnoid sharks. Environmental Biology Fishes, 38:95-114.

Guitar-Manday, D. 1966. Nuevo nombre para una especie de tiburon del genero *Isurus* (Elasmobranchii: Isuridae) de aguas cubanas. Poeyana (Ser. A), 1966(15):9 p.

Joung, S.J., J.J. Wu, and C.T. Chen. 1989. Six new records of sharks from Taiwan. J. Fisheries Society Taiwan, 16:239-245.

Killiam, K. and G. Parsons. 1986. First record of the longfin mako shark, *Isurus paucus*, in the Gulf of Mexico. Fishery Bulletin, 84:748-749.

Kronman, M. 2000. From predators to poster children. National Fishermen, March 2000:22-23, 52.

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